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[P : 27]

KNOCK CHARACTERISTICS OF MOTOR FUELS BY THE RESEARCH METHOD

(Third Reprint MARCH 1982)

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KNOCK CHARACTERISTICS OF MOTOR FUELS BY THE RESEARCH METHOD

(P : 27)

Adapted from ASTM Designation : *D* 908-58

1. SCOPE

1.1 This method describes the test for determining the knock characteristics, in terms of research octane numbers, of fuels for use in spark-ignition engines.

2. TERMINOLOGY

2.0 For the purpose of this method, the following definition shall apply.

2.1 Research Octane Number — The whole number nearest the percentage by volume of *iso*-octane (2, 2, 4-trimethylpentane) in a blend with normal heptane that matches the knock characteristics of the fuel when compared by this method.

2.1.1 The Research Octane Number of *iso*-octane equals 100 and that of normal heptane equals 0, by definition.

3. OUTLINE OF THE METHOD

3.1 The research octane number of a fuel is determined by comparing its knocking tendency with those for blends of the reference fuels of known octane number at 600 rpm under standard operating conditions. This is done by varying the compression ratio for the sample to obtain the standard knock intensity as defined by a guide curve and as measured by an electronically controlled knockmeter. When the knockmeter reading for the sample is bracketed between those for two reference blends differing by not more than two octane numbers, the rating of the sample is calculated by interpolation.

4. APPARATUS

4.1 The knock testing unit* consists of a single-cylinder engine of continuously variable compression ratio, with suitable loading and accessory equipment and instruments, mounted on a stationary base.

4.2 The panel-mounted detonation meter, Model 501-AP† and knockmeter, or desk-mounted Model 501-A shall be used to measure knock intensity

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* Further details about the apparatus, its installation, maintenance, etc, are given in 1956 ASTM Manual for Rating Motor Fuel by Motor and Research Methods and the 1957 Supplement.

† Available from the Waukesha Motor Co., Fuel Research Division, Waukesha, Wisconsin, USA, and The Solartron Electronic Group Ltd., Solartron Works, Queens Road, Thames Ditton, Surrey, England.

(detonation meter Model 501 may also be used). With the detonation meter, a pick up, Type D-1 is required and may be purchased with the meter. A constant voltage transformer (*see* Note 1) should be used to prevent instability of knockmeter readings due to the line voltage fluctuations.

NOTE 1 —The detonation meter requires a 115-V regulated voltage source and its total power requirements are less than 60 VA. Regulating and step-down regulating transformers for conversion of the line voltage to the instrument operating voltage may be purchased with the meter or from electrical supply houses. If the frequency of the power source is less than 50 cycles, a detonation meter altered to accommodate the particular frequency available shall be used.

5. REFERENCE MATERIALS

5.1 Knock Test Reference Fuels — These fuels can be produced as required by mixing the following hydrocarbons.

5.1.1 *Iso-Octane* (2, 2, 4-*trimethylpentane*) — This fuel in the pure state has, by definition, an octane number of 100.

5.1.2 *n-Heptane* — This is a low antiknock fuel, which in its pure state has, by definition, an octane number of 0.

5.1.3 *Seventy-five Octane Number Blend* — a blend by volume of 75 percent *iso*-octane and 25 percent *n*-heptane.

5.1.4 Any other blends of *iso*-octane and *n*-heptane as required.

5.2 Toluene — conforming to *IS:537-1955.

6. OPERATING CONDITIONS

6.1 The following standard operating conditions are mandatory.

6.1.1 *Engine Speed* — 600 ± 6 rpm, constant to within 6 rpm during a test.

6.1.2 *Spark Advance* — constant, 13·0 deg.

6.1.3 *Spark Plug Gap* — 0·51 ± 0·13 mm (or 0·020 ± 0·005 in).

6.1.4 *Breaker-Point Gap* — 0·51 mm (or 0·020 in).

6.1.5 *Valve Clearances* — 0·20 ± 0·02 mm (or 0·008 ± 0·001 in), measured with the engine hot and running under standard operating conditions on a reference fuel of 75 octane number.

6.1.6 *Crankcase Lubricating Oil* — SAE 30, having a kinematic viscosity range of 9·62 to 12·94 cS at 99°C (or 210°F).

6.1.7 *Oil Pressure* — 1·8 to 2·1 kg/cm^2 (or 25 to 30 lb/in ^{2}) under operating conditions.

6.1.8 *Oil Temperature* — 57·5 ± 8·5°C (or 135 ± 15°F) with the temperature sensitive element completely immersed in the crankcase oil.

6.1.9 *Coolant Temperature* — 100 ± 1·5°C (or 212 ± 3°F) constant within ± 0·5°C (or ± 1°F) during a test.

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*Since revised.

6.1.10 *Intake Air Humidity* — 3·5 to 7 mg of water vapour per gram (or 25 to 50 grains of water vapour per pound) of dry air. When air of this humidity prevails in the engine room through the operation of natural factors or air conditioning, it may be used without further conditioning, its humidity being determined by sling psychrometer. Otherwise the apparatus given in **6.1.10.1** may be used.

6.1.10.1 *Humidity-control apparatus* — The humidity may be controlled by means of the CFR ice tower which consists of an insulated cylindrical tank arranged to pass the engine-inlet air through an ice bed, thus chilling it and delivering saturated air approximately with a moisture content of 3·7 to 4·0 mg of water vapour per gram of dry air.

The tower is arranged to take air in at the top with a down-flow through the ice pack. The air leaves the tower through a tube at the centre of the ice pack, passing up from the bottom. This design permits the addition of ice without interrupting the engine operation. The centre tube provides a chilled outlet passage, thus preventing the evaporation of entrained moisture. It is recommended that a suitable water manometer be connected to the air outlet pipe of the ice tower to indicate undue restriction of the air flow.

The tank is made of galvanized sheet metal with 50 mm of rock-wool insulation of sides and bottom. The ice is supported on a ½-inch wire screen held 10 cm above the bottom of the tank to form a surge chamber. The outlet pipe connects through a pipe bend to the pipe, 113 cm long, leading to the combination surge tank, capacity 13 litres, and air heater located on the carburettor inlet pipe. Flexible rubber hose connexions in the air line permit adjustment of the compression ratio. The tower is supported on an angle-iron stand to allow convenient drainage through a trap at the bottom. A removable wood cover on the top permits convenient access for filling. The 75-mm opening in cover is the normal air inlet, which may be closed by a slide cover to economize when the engine is shut down.

The tower shall be charged with 5 cm lump ice. If the size is materially larger, channelling may occur; if smaller, the air supply to the engine may be restricted. The minimum depth of the ice bed shall be 45 cm.

As a safety precaution, a suitable water manometer may be connected to the air-outlet pipe of the ice tower. A differential pressure appreciably in excess of 12 mm of water indicates undue restriction of the air flow, resulting from improper condition of the ice or plugging of the drain tap.

6.1.11 *Intake Air Temperature* — measured at carburettor entrance with a mercury thermometer and maintained within ± 1·1°C (or ± 2°F) for the temperature specified for the prevailing barometric pressure in Table I.

6.1.12 *Carburettor Venturi* — with diameter 14·29 mm (or 9/16 in) at the throat.

TABLE I MICROMETER SETTINGS FOR STANDARD KNOCK INTENSITY AT A BAROMETRIC PRESSURE OF 760 mm (OR 29·92 in) OF MERCURY

For Use at All Altitudes, 14·29 mm (or 9/16 in) Venturi

(*See* Table II for corrections for other barometric pressures.)

RESEARCH OCTANE NUMBER	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	RESEARCH OCTANE NUMBER
	Micrometer Setting, in										
40	0·559	0·559	0·559	0·559	0·558	0·558	0·558	0·558	0·557	0·557	**40**
41	0·557	0·556	0·556	0·556	0·556	0·555	0·555	0·555	0·555	0·554	**41**
42	0·554	0·554	0·553	0·553	0·553	0·553	0·552	0·552	0·552	0·551	**42**
43	0·551	0·551	0·550	0·550	0·550	0·549	0·549	0·549	0·548	0·548	**43**
44	0·548	0·547	0·547	0·547	0·547	0·546	0·546	0·546	0·545	0·545	**44**
45	0·545	0·544	0·544	0·544	0·543	0·543	0·543	0·542	0·542	0·542	**45**
46	0·541	0·541	0·541	0·540	0·540	0·540	0·539	0·539	0·539	0·538	**46**
47	0·538	0·538	0·537	0·537	0·537	0·536	0·536	0·536	0·535	0·535	**47**
48	0·535	0·534	0·534	0·533	0·533	0·533	0·532	0·532	0·532	0·531	**48**
49	0·531	0·531	0·530	0·530	0·529	0·529	0·529	0·528	0·528	0·528	**49**
50	0·527	0·527	0·527	0·526	0·526	0·525	0·525	0·525	0·524	0·524	**50**
51	0·524	0·523	0·523	0·523	0·522	0·522	0·521	0·521	0·521	0·520	**51**
52	0·520	0·520	0·519	0·519	0·518	0·518	0·518	0·517	0·417	0·517	**52**
53	0·516	0·516	0·515	0·515	0·515	0·514	0·514	0·513	0·513	0·513	**53**
54	0·512	0·512	0·511	0·511	0·511	0·510	0·510	0·510	0·509	0·509	**54**
55	0·508	0·508	0·507	0·507	0·507	0·506	0·506	0·505	0·505	0·505	**55**
56	0·504	0·504	0·503	0·503	0·503	0·502	0·502	0·502	0·501	0·501	**56**
57	0·500	0·500	0·499	0·499	0·499	0·498	0·498	0·497	0·497	0·497	**57**
58	0·496	0·496	0·495	0·495	0·495	0·494	0·494	0·493	0·493	0·492	**58**
59	0·492	0·492	0·491	0·591	0·490	0·490	0·489	0·489	0·489	0·488	**59**
60	0·488	0·487	0·487	0·487	0·486	0·486	0·485	0·485	0·484	0·484	**60**
61	0·483	0·483	0·482	0·482	0·481	0·481	0·481	0·480	0·480	0·479	**61**
62	0·479	0·478	0·478	0·477	0·477	0·477	0·476	0·476	0·475	0·475	**62**
63	0·474	0·474	0·473	0·473	0·473	0·472	0·472	0·471	0·471	0·471	**63**
64	0·470	0·470	0·469	0·469	0·468	0·468	0·467	0·467	0·466	0·466	**64**
65	0·466	0·465	0·465	0·464	0·464	0·463	0·463	0·462	0·462	0·461	**65**
66	0·461	0·460	0·460	0·459	0·459	0·458	0·458	0·457	0·457	0·456	**66**
67	0·456	0·455	0·455	0·454	0·454	0·453	0·453	0·452	0·452	0·451	**67**
68	0·451	0·450	0·450	0·449	0·449	0·448	0·448	0·447	0·447	0·447	**68**
69	0·446	0·445	0·445	0·445	0·444	0·444	0·443	0·443	0·442	0·442	**69**
70	0·441	0·441	0·440	0·440	0·439	0·439	0·438	0·438	0·437	0·437	**70**
71	0·436	0·436	0·435	0·435	0·434	0·434	0·433	0·433	0·432	0·432	**71**
72	0·431	0·431	0·430	0·430	0·429	0·429	0·428	0·427	0·427	0·426	**72**
73	0·426	0·425	0·425	0·424	0·423	0·423	0·422	0·422	0·421	0·421	**73**
74	0·420	0·419	0·419	0·418	0·418	0·417	0·416	0·416	0·415	0·415	**74**
75	0·414	0·413	0·413	0·412	0·411	0·411	0·410	0·410	0·409	0·409	**75**
76	0·408	0·407	0·406	0·406	0·405	0·405	0·404	0·403	0·402	0·402	**76**
77	0·401	0·400	0·400	0·399	0·398	0·398	0·397	0·396	0·396	0·395	**77**
78	0·394	0·394	0·393	0·392	0·392	0·391	0·390	0·390	0·389	0·388	**78**
79	0·387	0·387	0·386	0·385	0·384	0·384	0·383	0·382	0·381	0·381	**79**
80	0·380	0·379	0·378	0·378	0·377	0·376	0·376	0·375	0·374	0·374	**80**
81	0·373	0·372	0·371	0·371	0·370	0·370	0·369	0·368	0·367	0·367	**81**
82	0·366	0·365	0·364	0·364	0·363	0·362	0·362	0·361	0·360	0·359	**82**
83	0·358	0·358	0·357	0·356	0·355	0·355	0·354	0·353	0·352	0·352	**83**
84	0·351	0·350	0·349	0·349	0·348	0·347	0·346	0·346	0·345	0·344	**84**
85	0·343	0·342	0·341	0·340	0·339	0·339	0·338	0·337	0·336	0·335	**85**
86	0·334	0·334	0·333	0·332	0·331	0·330	0·329	0·328	0·327	0·327	**86**
87	0·326	0·325	0·324	0·323	0·322	0·321	0·320	0·319	0·318	0·317	**87**
88	0·317	0·316	0·315	0·314	0·313	0·312	0·311	0·310	0·309	0·308	**88**
89	0·307	0·306	0·305	0·304	0·303	0·302	0·301	0·300	0·299	0·298	**89**
90	0·297	0·296	0·295	0·294	0·293	0·292	0·291	0·290	0·289	0·288	**90**
91	0·287	0·286	0·285	0·284	0·283	0·282	0·281	0·280	0·279	0·278	**91**
92	0·276	0·275	0·274	0·273	0·272	0·271	0·270	0·269	0·268	0·267	**92**
93	0·266	0·264	0·263	0·262	0·260	0·259	0·258	0·257	0·256	0·255	**93**
94	0·254	0·252	0·251	0·250	0·248	0·247	0·246	0·244	0·243	0·242	**94**
95	0·241	0·240	0·238	0·237	0·236	0·234	0·233	0·231	0·230	0·229	**95**
96	0·227	0·226	0·224	0·223	0·222	0·220	0·218	0·217	0·216	0·214	**96**
97	0·213	0·211	0·210	0·208	0·206	0·205	0·203	0·202	0·200	0·199	**97**
98	0·197	0·195	0·193	0·192	0·190	0·188	0·186	0·184	0·182	0·180	**98**
99	0·179	0·177	0·175	0·174	0·172	0·169	0·167	0·165	0·163	0·162	**99**
100	0·160	—	—	—	—	—	—	—	—	—	**100**

6.1.13 *Micrometer Adjustment* — set to read 0·500 in (5·5 to 1 compression ratio) with the piston at top dead centre and with a clearance volume of 140·0 ± 0·5 ml to the top face of the pick-up hole on cylinder of standard bore.

6.1.14 *Fuel-Air Ratio* — adjusted for maximum knock as follows:

> At each compression ratio and for each fuel being tested, adjust the fuel-air ratio by varying the carburettor float level in increments, until the adjustment that produces a maximum knockmeter reading is obtained. It is required that this float level setting be between 20·3 to 45·7 mm (or 0·8 to 1·8 in); it may be necessary to change the size of the metering jets to meet this requirement.

6.1.15 *Standard Knock Intensity* — obtained with a blend of *iso*-octane and normal heptane, under the standard operating conditions of this method and at a micrometer reading corresponding to the octane number of the blend used and the prevailing barometric pressure in accordance with Table I and the correction Table II.

7. STARTING AND STOPPING ENGINE

7.1 Starting the Engine — While the engine is being motored, turn on the ignition and start the engine by setting the carburettor to draw fuel from one float bowl.

7.2 Stopping the Engine — Turn off the fuel, then the ignition, drain all fuel bowls, and motor the engine for one minute before stopping the synchronous motor. To avoid possible corrosion and warping of valves and seats between operating periods, close both valves by turning the flywheel to top dead centre on the compression stroke.

8. OBTAINING STANDARD KNOCK INTENSITY

8.1 With the engine at equilibrium temperature and the carburettor set for maximum knock, obtain standard knock intensity (*see* **6.1.15**), at the micrometer setting obtained from Table I and corrected in accordance with Table II for the octane number of the reference fuel blend being used and the barometric pressure at the time of the test. The intake air temperature should be adjusted to correspond with the value specified for the prevailing barometric pressure as given in Table II. When the barometric pressure is measured by a mercurial barometer having a brass scale, correct the reading for ambient temperature by the following formula:

$$B = b - 0{\cdot}000\,162\,b\,(t + 1{\cdot}94)$$

where

B = corrected barometric pressure, in mm (or in) of mercury;
b = observed barometric pressure, in mm (or in) of mercury; and
t = observed temperature of the barometer, in degrees Centigrade.

TABLE II INTAKE AIR TEMPERATURES AND CORRECTIONS TO BE APPLIED TO MICROMETER SETTINGS IN TABLE I AND TO OBSERVED MICROMETER READINGS FOR VARIOUS BAROMETRIC PRESSURES*

Barometric Pressure		0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	Barometric Pressure
	To Correct Micrometer Setting for the Prevailing Barometric Pessure **SUBTRACT** the following Micrometer Values from the Values in Table I: To Correct the Observed Micrometer Setting for the Prevailing Barometric Pressure **ADD** the following Micrometer Values to the Micrometer Reading :											
21·0	Micrometer Corrections	0·223	0·221	0·218	0·216	0·213	0·211	0·208	0·206	0·203	0·201	21·0
	Intake Air Temperatures	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	
22·0	Micrometer Corrections	0·198	0·196	0·193	0·191	0·188	0·186	0·183	0·181	0·178	0·176	22·0
	Intake Air Temperatures	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	
23·0	Micrometer Corrections	0·173	0·171	0·168	0·166	0·163	0·161	0·158	0·156	0·153	0·151	23·0
	Intake Air Temperatures	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	
24·0	Micrometer Corrections	0·148	0·146	0·143	0·141	0·138	0·136	0·133	0·131	0·128	0·126	24·0
	Intake Air Temperatures	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	15·6	
25·0	Micrometer Corrections	0·123	0·121	0·118	0·116	0·113	0·111	0·108	0·106	0·103	0·101	25·0
	Intake Air Temperatures	15·6	15·6	15·6	15·6	15·6	15·6	16·1	17·2	17·8	18·9	
26·0	Micrometer Corrections	0·098	0·096	0·093	0·091	0·088	0·086	0·083	0·081	0·078	0·076	26·0
	Intake Air Temperatures	19·4	20·6	21·1	22·2	22·8	23·9	24·4	25·6	26·1	27·2	
27·0	Micrometer Corrections	0·073	0·071	0·068	0·066	0·063	0·061	0·058	0·056	0·053	0·051	27·0
	Intake Air Temperatures	27·8	28·9	29·4	30·0	31·1	31·7	32·8	33·3	34·4	35·0	
28·0	Micrometer Corrections	0·048	0·046	0·043	0·041	0·038	0·036	0·033	0·031	0·028	0·026	28·0
	Intake Air Temperatures	36·1	36·7	37·8	38·3	39·4	40·0	41·1	41·7	42·8	43·3	
29·0	Micrometer Corrections	0·023	0·021	0·018	0·016	0·013	0·011	0·008	0·006	0·003	0·001	29·0
	Intake Air Temperatures	43·9	45·0	45·6	46·7	47·2	48·3	48·9	50·0	50·6	51·7	
	To Correct Micrometer Setting for the Prevailing Barometric Pressure **ADD** the following Micrometer Values to the Values in Table I: To Correct the Observed Micrometer Setting for the Prevailing Barometric Pressure **SUBTRACT** the following Micrometer Values from the Micrometer Reading :											
30·0	Micrometer Corrections	0·002	0·004	0·007	0·009	0·012	0·014	0·017	0·019	0·022	0·024	30·0
	Intake Air Temperatures	52·2	52·8	53·9	54·4	55·6	56·1	57·2	57·8	58·9	59·4	

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* Convert the barometric pressure in millimetres to inches by multiplying by 0.039 37 before using Table II.

If the observed temperature is in degree Fahrenheit, use the following formula:

$$B = b - 0{\cdot}000\,09\, b\,(t - 28{\cdot}5)$$

No correction is required for a properly compensated aneroid barometer, but it should be calibrated at least once a year.

9. ADJUSTING KNOCKMETER, AND DETONATION METER

9.1 Zero Adjustment of Knockmeter — Before daily operation, with power and operational switches of the detonation meter in the OFF position, check zero of knockmeter. Reset as necessary using adjusting screw provided on knockmeter face.

9.2 Zero Adjustment of Detonation Meter — With the power switch in the ON position, warm up the meter for about 30 minutes. Then with the operational switch in the OFF position, and the METER READING and SPREAD controls in their approximate normal operating positions, check zero of knockmeter. If adjustment is necessary, remove the screw cap marked ZERO on the detonation meter, and make adjustment with a small screw-driver to bring the knockmeter pointer to zero.

Although the ZERO adjustment of the Detonation Meter is not critical, it is good practice to recheck it from time to time to compensate for tube ageing and after installation of replacement tubes and parts.

9.3 Adjustments of Time Constant — The TIME CONSTANT control switch has six positions. Position No. 1 gives the fastest and position No. 6 the slowest meter response, with other positions being intermediate.

9.4 Adjustments of Detonation Meter Reading and Spread — The controls for the METER READING (marked Sensitivity on earlier meters) and SPREAD are made so that each control has both a coarse and a fine adjustment, with indexes for resetting.

The fine and coarse knobs are independent of each other. The coarse knob should be used to obtain the approximate reading required, and the fine knob is used for more precise adjustment. It is not necessary to change these controls very much to cover the range 40 to 100 octane number, particularly if the initial setting of the meter is made at 85 octane number. However, this does not preclude making a setting at any desired octane level in order to follow the appropriate guide table. It probably will be necessary to reset the meter for use above 100 octane number or below 40 octane number.

With the engine operating under standard test conditions on a reference fuel, adjust the meter reading and spread as follows: Turn the knobs (fine and coarse) marked METER READING and SPREAD fully counterclockwise. Rotate the coarse knob on the SPREAD dial clockwise approximately 15 deg and the fine knob approximately 150 deg; rotate the METER

READING coarse knob clockwise so that the Knockmeter pointer is approximately mid-scale, and use the fine knob for precise control. Adjust the fuel-air ratio for maximum knock. If the maximum is not well defined, this is an indication that the sensitivity to change in octane number is too small. To increase the sensitivity, rotate the SPREAD knobs clockwise until the meter reads 100, then rotate the METER READING knobs counter-clockwise until the meter is near mid-scale again.

Change to the carburettor tank containing the second reference fuel which differs from the first by not more than two octane numbers and determine its fuel-air ratio for maximum knock. The spread may then be determined by comparing the maximum readings for the two reference fuels. A desirable spread for two octane numbers is 15 to 30 divisions. However, in the low octane number range, it may be necessary to use a smaller spread, but it should never be less than six knockmeter divisions per two octane numbers.

If the spread is too small, increase the knockmeter reading approximately 20 divisions by rotating the SPREAD knobs clockwise; then rotate the METER READING knobs counter-clockwise to restore the original reading. If the spread is not sufficient, repeat the procedure. Rotating the SPREAD knobs clockwise increases the spread; to decrease the spread, reverse this procedure. After the desired spread is obtained, the detonation meter is ready for use and a check should be made with an appropriate standardization fuel.

10. CHECKING TEST CONDITIONS

10.1 Engine conditions are not correct unless a blend of 74 percent of toluene and 26 percent of normal heptane by volume matches a blend of 93·4 ± 0·3 percent *iso*-octane and 6·6 ± 0·3 percent normal heptane by volume. If this match cannot be obtained under standard conditions, check the mechanical conditions of the engine. Other standardization fuels may be used for checking both engine and test conditions at this and other octane number levels. Their ratings should fall within ± 0·3 octane number of the value given in the appropriate certified calibration table.

10.2 For subsequent testing of fuel samples, adjust the cylinder height for standard knock intensity, using the knockmeter as a guide, provided no change has been made in the detonation meter adjustment in the meantime. Make certain that the cylinder heights as measured by micrometer settings are within ± 0·010 in. of those given in guide Table I, corrected from Table II for the prevailing barometric pressure, for the octane numbers of the reference fuel blends that match the samples. An adjustment of the intake air temperature in accordance with Table II may be required if a significant change in barometric pressure occurs during the day.

10.3 The engine should cease firing instantly when the ignition is switched off. If it does not, operating conditions are unsatisfactory. Examine the engine for defects, particularly for combustion chamber and spark-plug deposits, and remedy such conditions before rating fuels.

11. ADJUSTING COMPRESSION RATIO AND CARBURETTOR

11.1 It is necessary to make an approximate adjustment of the compression ratio before setting the fuel level for maximum knock, after which make the final adjustment of the compression ratio to give standard knock intensity.

11.2 Preliminary Adjustment of Compression Ratio — Fill one tank of the carburettor with the sample and turn the selector valve to draw fuel from the bowl. Set the fuel level to give approximately maximum knockmeter reading and adjust the compression ratio to give a knockmeter reading of about 55 scale divisions. As any necessary readjustments will increase the knockmeter reading, time can be saved by setting for 52 or in some cases even lower.

11.3 Adjustment of Fuel-Air Ratio — Adjust the fuel level for the position of maximum knock as follows:

> With a setting, for example, of 1·3 in. on the etched glass scale, allow the knockmeter to reach equilibrium and record the reading. Then obtain and record knockmeter readings for richer fuel-air ratios by raising the fuel level by 0·1 in. increments to settings of 1·2, 1·1, . . . until the knockmeter reading has decreased at least five divisions from the maximum. Reset the fuel level at the position for which the maximum knockmeter reading was obtained, for example, 1·2 in. Follow the same procedure for leaner fuel-air ratios by setting in turn at 1·3, 1·4, . . . until the knockmeter reading has decreased at least five divisions from the maximum. Set the fuel level at the position for which the maximum knockmeter reading was obtained, or between the two positions for which the reading was the same, for example, 1·25 in. This is the position for maximum knock. Verify it at least once by settings at levels 0·1 in. on either side; in the example just taken, at both 1·15 and 1·35 in. If higher knockmeter readings are obtained at either of these positions, the setting is in error and repetition of the entire procedure is necessary. For each setting of the fuel level allow the knockmeter to reach equilibrium before recording readings.

11.4 Carburettor Cooling — If a tendency for the sample to bubble or boil in the fuel-level sight glass is observed when making the adjustments in **11.3**, it is recommended that a carburettor cooling apparatus may be used. For normal conditions, however, carburettor cooling shall not be used.

11.5 Final Adjustment of Compression Ratio — Finally, adjust the compression ratio to give a knockmeter reading of 55 ± 3 scale divisions. Use this setting for the remainder of the test.

12. BRACKETING THE TEST FUEL

12.1 First Bracketing Reference Fuel — Based on the expected knock rating of the sample, place a trial blend of the knock-test reference fuels, which has been *thoroughly* mixed, in another of the carburettor tanks. Operate the engine on it, without changing the compression ratio, while the level of the float bowl is adjusted to the maximum knock position as described in **11.3**.

12.2 Second Bracketing Reference Fuel — Select a second trial blend of the reference fuels such that the maximum knockmeter reading obtained for the sample will be between those obtained for the reference fuel blends. Place the second trial blend in the third carburettor tank and operate the engine on it, without changing the compression ratio, while the level of the float is adjusted to the maximum knock position as described in **11.3**. If the octane numbers of the first and second trial blends do not differ by more than two units, continue the test; otherwise try additional blends of reference fuels until this requirement is met.

12.3 Obtaining Knockmeter Readings — With the three carburettor bowls set at the fuel-air ratios giving maximum knockmeter readings, take a series of readings for the sample and the two reference fuel blends. In each case allow the knockmeter to reach equilibrium before recording the reading. Bracket the sample between the two blends of reference fuels at least three times. A convenient way to do this is to take readings in order for the second reference fuel, the sample, the first reference fuel, the sample, the second reference fuel, the sample, and the first reference fuel. In changing fuels, always allow at least one minute for the engine and knockmeter to reach equilibrium. With some fuels an appreciably longer time interval may be required.

13. REPORTING OF RESULTS

13.1 Average the knockmeter readings obtained in accordance with **12.3** for the sample and for each of the reference fuel blends. Find the research octane number by interpolation from the averages so obtained.

13.2 Report the octane number to nearest integer. When the interpolated figure ends with 0·50, round off to the nearest even number; for example, report 99·50 as 100, not 99.

14. PRECISION

14.1 Extensive data from independent laboratories over a number of years for many samples of conventional motor gasolines have shown a standard deviation of 0·5 octane number (an average deviation of about 0·4 octane number). Based on this standard deviation, the number of tests required to yield a rating of desired accuracy is given below:

Accuracy Desired, Octane Number,	Number of Tests Required to Obtain the Desired Accuracy		
Plus or Minus	9 times out of 10	19 times out of 20	99 times out of 100
1·0	1	1	2
0·5	3	4	7
0·3	8	11	18

This table shows that a single rating is normally expected to be within ± 1·0 octane number of the true value in about 19 cases out of 20. On the other hand, if an accuracy of ± 0·3 octane number is desired with a certainty of 90 percent (9 times out of 10) it is necessary to obtain an average of eight ratings in eight different engines (preferably in eight independent laboratories).

Although the above degree of reproducibility applies to conventional motor gasolines when careful attention is given to the details of test procedure and engine condition, it does not necessarily apply to fuels which differ materially from finished motor gasolines. In such cases, the reproducibility is likely to be lower and result in higher standard deviations.

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